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(54) METHOD OF SPLITTING HANDWRITTEN INPUT

VERFAHREN ZUR HANDSCHRIFT-EINGANGSAUFTEILUNG

PROCEDE PERMETTANT DE FRACTIONNER UNE ENTREE MANUSCRITE

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- **PATTERN RECOGNITION, ROME, NOVEMBER 14 - 17, 1988, vol. VOL. 2, no. 1988, 14 November 1988, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 1138-1142, XP000013050 KOJIMA H ET AL: "ON-LINE HAND-DRAWN LINE-FIGURE RECOGNITION AND ITS APPLICATION"**

EP 0 739 521 B1

Description

Field Of The Invention

[0001] This invention relates generally to handwriting recognition, and more particularly to the selection input and editing of discrete continuous segments of handwritten input.

Background of the Invention

[0002] Machine recognition of human handwriting is a very difficult problem, and with the recent explosion of pen-based computing devices, has become an important problem to be addressed. Machine recognition of human handwriting has various present applications.

[0003] One example of the current application for machine recognition of human handwriting is found in personal digital assistants, such as the Newton product and other types of pen based computing devices. Typically these type of products have a touch sensitive screen upon which a user can impose handwriting. These devices then function to digitize the handwritten input, such as alphanumeric input, and thereafter process the input in an attempt to recognize the information content of the handwriting.

[0004] Pursuant to one prior art handwriting recognition technique, one makes a best determination as to the identity of each alphanumeric character in sequence, with the resulting string of characters comprising the result of the recognition activity. There are a variety of drawbacks to this approach. It is hindered by the difficulty of identifying spatial boundaries of the candidate inputs (in this case alphanumeric characters to be recognized. When these boundaries are not located correctly, it is impossible to recognize the character accurately, since it will either be lacking pieces or will incorporate extraneous material from adjacent characters.

[0005] One significant problem with machine recognition of human handwriting is the ability to recognize the end of one input and the beginning of the next input. For example, a significant problem exists in locating the end of one handwritten input segment, word, or alphanumeric input, from the beginning of the subsequent handwritten input segment, word, or alphanumeric input. Poor recognition of the handwritten input results in poor, inaccurate interpretation of the information content of the handwritten input. This problem is accented by poor input practices of the user or input device, such as poor penmanship or handwriting habits. Machine recognition of handwritten input may incorrectly join one or more segments of handwritten input into one segment, and recognize them as them as a singular discrete segment. Alternatively, a user may feel the need to split one or more handwritten input segments after such segments have been entered as a singular discrete handwritten input segment.

[0006] Accordingly, a need exists for a handwriting recognition technique that allows a user or input device to enter a selection input edit instruction that permits the user, or input device, to split one or more continuous segments to form one or more discrete continuous segments for recognition and display and thereby provide a more accurate interpretation of the information content of the handwritten input. This technique is provided by the invention as specified in claim 1.

Brief Description Of The Drawings

[0007]

FIG. 1 Illustrates a flow diagram of operation in accordance with a preferred embodiment of the present invention.

FIG. 2 Illustrates a graphical view of an illustrative display in accordance with a preferred embodiment of the present invention.

FIG. 3 Illustrates a graphical view of an illustrative display in accordance with a preferred embodiment of the present invention.

FIG. 4 Illustrates a graphical view of an illustrative display in accordance with a preferred embodiment of the present invention.

FIG. 5 Illustrates a graphical view of an illustrative display in accordance with a preferred embodiment of the present invention.

FIG. 6 Illustrates a graphical view of an illustrative display in accordance with a preferred embodiment of the present invention.

FIG. 7 Illustrates a graphical view of an illustrative display in accordance with a preferred embodiment of the present invention.

Detailed Description Of The Preferred Embodiments

[0008] Generally, the present invention as disclosed provides a user with the option of editing handwritten input such that the user may elect to split one or more continuous segments, or blocks of ink, to form one or more discrete continuous segments. The split discrete segments are then presented as individual discrete continuous segments and analyzed as individual discrete segments by the method of machine recognition of handwritten input being employed by a device that functions to receive handwritten input, such as a Personal Digital Assistant (PDA). The recognition of the individual discrete segments that result is then displayed to the user.

[0009] In a preferred embodiment of the present invention the handwritten input is alphanumeric, the writ-

ing axis is horizontal, and the writing direction is left to right. In accordance with this preferred embodiment, the handwritten input and the resultant recognition are displayed concurrently and in close juxtaposition to each other. This close juxtaposition allows the user to refer to their original handwritten input when correcting errors in the processing and recognition of the handwritten input.

[0010] Typically, handwritten character input is collected from the user in the form of discrete continuous segments. A discrete continuos segment consists of one or more pen strokes, where a pen stroke is the mark left by a pen during its period of contact with an input device such as a digitizing tablet or paper. A stroke is represented as a sequence of points sampled at approximately regular intervals by the input device. Each point is described at minimum by an X coordinate and a Y coordinate. Strokes may be captured electronically using a digitizing tablet, or in alternative embodiments may be derived from a scanned or faxed image through a process of line detection in the image; such methods of capturing input electronically are understood in the art.

[0011] In the present invention one or more discrete continuous segments are the units of handwritten input being recognized. Handwritten input is input which is captured electronically that includes but is not limited to the following: handwritten input; electronic input; input captured through pressure, such as stamped input; input that is received electronically, such as via facsimile, pager, or other device. For purposes of explanation of the present invention, handwritten input is typically presented along a writing axis in a direction which is defined as the writing direction. The writing axis is the line along which the handwritten input is added. The writing direction is the direction in which each subsequent handwritten input is added. For example, in English, handwritten input is added typically along a horizontal writing axis with each subsequent alphanumeric input following horizontally after the previous input in a writing direction that is left to right. Various other writing axis and writing direction alternatives are possible with the implementation of the teachings of the present invention.

[0012] In a preferred embodiment, the handwriting axis is horizontal and the handwritten input forms a series of words. In this preferred embodiment, the continuous discrete segments are entered horizontally from left to right. In an alternative preferred embodiment, the handwriting axis is horizontal and the handwritten input forms a series of separate characters, which may be alphanumeric characters, ideographic characters as found in languages such as Chinese, or other forms of characters or symbols of written communications. In this alternative embodiment, the output tells whether the discrete continuous segments belong to separate characters. In another preferred embodiment, the handwriting axis is vertical and the handwritten input forms a series of separate characters, which may be alphanumeric characters, ideographic characters, or other handwritten input. In this preferred embodiment, the writing axis is vertical and the output tells whether the discrete continuous segments belong to separate characters. In another preferred embodiment, the handwriting axis is vertical and the handwritten input forms a series of separate words, alphanumeric input, or other handwritten input, such as a vertical list of words, or numbers. In this preferred embodiment, the writing axis is vertical and the output tells whether the discrete continuous segments belong to separate handwritten input, such as separate words.

[0013] As disclosed above and as will be discussed further, the present invention demonstrates through the disclosure of several of the preferred embodiments that the writing axis may exist at any angle and the handwritten input may be interpreted more generally as corresponding to discrete elements (including but not limited to characters and words) containing one or more discrete continuous segments. The application of the methods described herein to any of various preferred embodiments requires only a change in the coordinate system used and such modifications can be made in accordance with the teachings presented.

[0014] Referring now to the Figures, a personal digital assistant (PDA) is generally depicted by reference numeral **100**. The PDA **100** depicted constitutes a generic representation and may be comprised for example of a Newton® or other pen based computing device. Such devices typically include a housing and a touch screen upon which input, such as words, can be handwritten using an appropriate hand manipulated stylus, or other input device. Such PDA and pen based computing devices typically include one or more microprocessors or other digital processing devices. These devices comprise computational platforms that can be readily programmed in accordance with the teachings presented herein. It should be understood that, while such personal digital assistants and pen based computing devices comprise a ready platform to accommodate the practice of applicant's teachings, the teachings presented herein may be practiced in a variety of other operating environments as well. Some examples of such environments include computers with digitizing screens, or which are connected to a digitizing input surface, or capable of receiving faxed or scanned image input, or digital or interactive televisions, modems, pagers, or other systems with the ability to capture handwritten input and process it.

[0015] Referring now to FIG 1, a preferred method of the present invention is illustrated. The present invention is applicable to one or more handwritten inputs of continuous segments. The preferred embodiments of the present invention are applicable to handwritten inputs having two or more strokes in a continuous segment. The use of three continuous segments S_1, S_2, and S_3 of alphanumeric input are for illustrative purposes only. For illustrative purposes S_1, S_2, and S_3 represent S_n, S_{n+1}, and S_{n+2} respectively. In the preferred method illustrated in FIGs 1 through 7, handwritten input consist-

ing of one or more continuous segments is received by an input device 110 , such as a personal digital assistant 100, or other device capable of capturing handwritten input. The handwritten input is analyzed by the handwriting recognition method executing on the input device , to provide recognition 115 , in this embodiment alphanumeric, that represents the corresponding handwritten input. In accordance with this preferred embodiment, the recognition of the continuous segments S_1, S_2, and S_3 is displayed to the user 120. Preferably, the recognition of S_1, S_2, and S_3 is displayed in close juxtaposition to a digitized representation of the original handwritten input of S_1, S_2, and S_3. Once the recognition is displayed 120, the user may select to input, or edit, 125 the displayed recognition 120 of S_1, S_2, and S_3. If the user, or input device, does not enter a selection input a recognition is displayed 130 for the one or more continuous segments S_1, S_2, and S_3 of handwritten input. If, however, the selection input is a split command, or instruction, then the continuous segments S_1, S_2, and S_3 are analyzed according to the strokes in each segment and are split into one or more discrete segments dependent if the stroke analysis indicates a gap exists among or between the continuous segments S_1, S_2, and S_3. Preferably, upon the receipt of a split instruction the contiguous segments S_1, S_2, and S_3 are parsed according to the strokes T in each segment S_1, S_2, and S_3 (see Figs. 2-7). Preferably the strokes are enumerated in temporal order, i.e. the order in which the user enters them; or input device receives them. This order is not necessarily the order that they appear along the writing axis. For example if the writing axis is left to right, a stroke T_n which is written first may appear after a stroke T_{n+1}. For example the upward stroke of the cursive letter "i" may be stroke Tn, but the stroke of the "dot" of the "i" , which is T_{n+1} may appear on a the writing axis before the stroke T_n.

[0016] In the preferred embodiment of the present invention, once the continuous segments S_1, S_2, and S_3 are parsed into their respective strokes, a map of the smallest gap that exist between each stroke and all other strokes of the continuous segments S_1, S_2, and S_3 is generated 135 and recorded. For each stroke, a value is recorded on the map. The value that is recorded is the largest of the values found of smallest gaps for that stroke as compared to every other stroke of the segments S_1, S_2, and S_3. As illustrated in FIG 1, 140, the value Z is recorded because it is the largest value found of those values corresponding to the smallest gaps that exist between a particular stroke T_n and all other strokes $T_{n+/-1 ...}$ of the continuous segments S_1, S_2, and S_3. Graphic illustrations of the value of Z are shown in FIGs 2 - 7. If the value of Z for each stroke is less than zero the contiguous segments S_1, S_2, and S_3 are concluded to be a single continuous handwritten input and is diplayed to the user, or input device, as such 130. However, if the value of Z, for any stroke T, is greater than zero, the one or more continuous segments S_1, S_2, and S_3, are split at the stroke number Tx having the largest value Z 150; where T_x is defined as the split stroke number. If a split stroke number is found, at least one discrete segment S_x is generated 155, where S_x includes the discrete continuous segments from stroke T = Zero to the split stroke number T_x. At least a second discrete segment S_y is generated 160, where S_y includes the discrete continuous segments from split stroke number plus one, T_{x+1}, to the last stroke T_{end} of the continuous segments S_1, S_2, and S_3. In accordance with the preferred embodiment of the present invention, the discrete continuous segments S_x and S_y are each analyzed and recognized as separate, distinct handwritten inputs by the handwriting recognition method executing on the input device 165. The teaching of the present invention may be employed by a variety of handwriting recognition methods. The recognition for both S_x and S_y is displayed to the user or input device 170. Preferably, the recognition of S_x and S_y is displayed in close juxtaposition to a digitized representation of the original handwritten input of continuous segments S_1, S_2, and S_3, or a to a digitized representation of the handwritten input divided according to the discrete segments S_x and S_y. Once the recognition of S_x and S_y is displayed 170, the user, or input device, may repeat a selection input split instruction and may select to split the discrete segments S_x and S_y, if possible. In accordance with the preferred method of the present invention a user may continue with one or more selection input instructions until the user no longer selects a split instruction or there are no discrete continuos segments remaining to split.

[0017] Referring now to FIGs 2 through 7, a graphical representation of a preferred embodiment of the present invention is illustrated. FIGs 2 through 4, illustrate an input device 110 upon which is received the handwritten input consisting of continuous segments S_1, S_2, and S_3. The continuous segments are recognized as a single continuous segment Sa and are displayed to the user or input device as such. In accordance with a preferred embodiment of the present invention as selection input is requested by the user, or input device. The selection input 125 is a split instruction, as illustrated in FIG. 3. FIG 4 illustrates the recognition and display of the discrete continuous segments S_x and S_y after the continuous segments S_1, S_2, and S_3 were parsed into strokes and processed according to a preferred method substantially similar to the method illustrated in FIG 1. The advantage of the present invention allows a user, or input device to join split an infinite amount of continuous segments S_n, $S_{n+/-1}$, $S_{n+/-2}$, etc., either repeatedly or simultaneously, to form separate individual discrete segments S_x, S_y, etc. This provides a user, or input device, a variety of editing capabilities.

[0018] FIGs. 5 through 7, illustrate a preferred method substantially similar to the method illustrated in FIG 1, as steps 125 through 188. In this preferred embodiment, the continuous segments S_1, S_2, and S_3 are parsed into strokes T_0 through T_{end}. A map of the smallest gaps be-

tween each stroke and all other strokes of the continuous segments S_1, S_2, and S_3, is generated. In this map the largest value, Z, 125, is recorded for each stroke, where Z is equal to the largest value found for each stroke, from the list of values of the smallest gaps found between that stroke and all other strokes. If map generated indicates Z is less than or equal to zero the continuous segment is found to be a single discrete handwritten input. This is illustrated in FIG 5, the continuous segment S_1 is deemed to be a single discrete handwritten input, in this example a single word that should not be split.

[0019] As illustrated in FIG 6 - 7, if however the value of Z is greater than zero for any of the strokes T, the one or more continuous segments S_1, S_2, and S_3, are split at the stroke number T_x having the largest value Z 150; where T_x is defined as the split stroke number. If a split stroke number is found, at least one discrete segment S_x is generated 155, where S_x includes the discrete continuous segments from stroke T = Zero to the split stroke number T_x. At least a second discrete segment S_y is generated 160, where S_y includes the discrete continuous segments from split stroke number plus one, T_{x+1}, to the last stroke T_{end} of the continuous segments S_1, S_2, and S_3. In accordance with the preferred embodiment of the present invention, the discrete continuous segments S_x and S_y are each analyzed and recognized as separate, distinct handwritten inputs by the handwriting recognition method executing on the input device 165. The recognition for both S_x and S_y is displayed to the user or input device 170.

Claims

1. A method for facilitating recognition of handwritten input, comprising the steps of:
   receiving:
   electronic data comprising a series of data points that correspond to an original handwritten input of continuous segments and recognized words that correspond to said original handwritten input of continuous segments evaluated together:
   displaying the recognized words;
   receiving user selection input comprising a split instruction; and upon receiving the split instruction:
   automatically determining a split position generating discrete continuous segments S_x and S_y on either side of said split position;
   receiving recognized words that correspond to each of discrete continuous segments S_x and S_y evaluated separately; and
   displaying said recognized words that correspond to discrete continuous segments Sx and Sy.

2. A method for facilitating recognition of handwritten input according to claim 1, the method further comprising the steps of:
   parsing the series of data points into a series of strokes generating a map of the largest value for each of the values of the smallest gaps of each stroke as compared to every other stroke; wherein
   upon generating a value greater than zero splitting said one or more continuous segments at a split stroke number T_x, said split stroke number having the largest value of said maps among the total number of strokes;
   generating at least one discrete continuous segment S_x incorporating the strokes from a first stroke T_0 to the split stroke number T_x; and
   generating at least one discrete continuous segment S_y incorporating the strokes from a first stroke equal to split stroke number plus one, $T_x + 1$, to a final stroke equal to T_{end}.

Patentansprüche

1. Ein Verfahren zur Erleichterung der Erkennung handschriftlicher Eingaben, das die folgenden Schritte aufweist:
   Empfang elektronischer Daten, die eine Folge von Datenpunkten aufweisen, die einer ursprünglich handschriftlichen Eingabe aus kontinuierlichen Segmenten entsprechen, und erkannte Wörter, die der ursprünglich handschriftlichen Eingabe aus kontinuierlichen Segmenten entsprechen, die zusammen evaluiert wurden;
   Anzeige der erkannten Wörter;
   Empfang einer Anwenderauswahleingabe, die eine Aufteilungsanweisung aufweist; und
   bei Empfang der Aufteilungsanweisung automatische Bestimmung einer Aufteilungsposition und Erzeugung einzelner kontinuierlicher Segmente S_x und S_y auf beiden Seiten der Aufteilungsposition;
   Empfang erkannter Wörter, die jedem der einzelnen kontinuierlichen Segmente S_x und S_y, die getrennt evaluiert wurden; und
   Anzeige der erkannten Wörter, die jedem der einzelnen kontinuierlichen Segmente S_x und S_y entsprechen.

2. Ein Verfahren zur Erleichterung der Erkennung

handschriftlicher Eingaben nach Anspruch 1, und das Verfahren weiter die folgenden Schritte aufweist:

Zergliedern der Folge von Datenpunkten in eine Folge von Schreibzügen und Erzeugung einer Karte des größten Wertes für jeden der Werte der kleinsten Lükken eines jeden Schreibzuges im Vergleich mit jedem anderen Schreibzug; wobei

bei Erzeugung eines Wertes größer Null dieser eine oder mehrere kontinuierliche Segmente bei einer Aufteilungsschreibzugnummer T_x aufgeteilt werden, und die Aufteilungsschreibzugnummer den größten Wert der Karten unter der gesamten Anzahl von Schreibzügen hat;

Erzeugung von wenigstens einem einzelnen kontinuierlichen Segment S_x, das die Schreibzüge von einem ersten Schreibzug T_0 bis zur Aufteilungsschreibzugnummer T_x verkörpert; und

Erzeugung von wenigstens einem einzelnen kontinuierlichen Segment S_y, das die Schreibzüge von einem ersten Schreibzug, welcher der Aufteilungsschreibzugnummer plus Eins entspricht, T_{x+1}, bis zu einem letzten Schreibzug, der T_{ende} entspricht, verkörpert.

Revendications

1. Procédé permettant de facilter la reconnaissance de l'écriture manuscrite, comprenant les étapes consistant à :
   recevoir :

   des données électroniques comprenant une série de points de données qui correspondent à une entrée manuscrite originale de segments continus et de mots reconnus qui correspondent à ladite entrée manuscrite originale de segments continus évalués ensemble ;
   afficher les mots reconnus ;
   recevoir l'entrée de sélection de l'utilisateur comprenant une instruction de fractionnement ; et
   lors de la réception de l'instruction de fractionnement :

   déterminer automatiquement une position de fractionnement ;
   générer des segments continus discrets S_x et S_y de chaque côté de ladite position de fractionnement ;
   recevoir des mots reconnus qui correspondent à chacun des segments continus discrets S_x et S_y évalués séparément ; et
   afficher lesdits mots reconnus qui correspondent aux segments continus discrets S_x et S_y.

2. Procédé permettant de faciliter la reconnaissance de l'écriture manuscrite selon la revendication 1, le procédé comprenant en outre les étapes consistant à :

   analyser du point de vue syntaxique la série de points de données dans une série de traits
   générer une carte de la plus grande valeur pour chacune des valeurs des plus petits interstices de chaque trait par rapport à tous les autres traits ; dans lequel
   lors de la génération d'une valeur supérieure à zéro
   fractionner ledit ou lesdits segments continus en un nombre de traits fractionnés T_x, ledit nombre de traits fractionnés ayant la plus grande valeur desdites cartes parmi le nombre total de traits ;
   générer au moins un segment continu discret S_x incorporant les traits d'un premier trait T_0 au nombre de traits fractionnés T_x ; et
   générer au moins un segment continu discret S_y incorporant les traits d'un premier trait égal au nombre de traits fractionnés T_{x+1} à un trait final égal à T_{fin}.

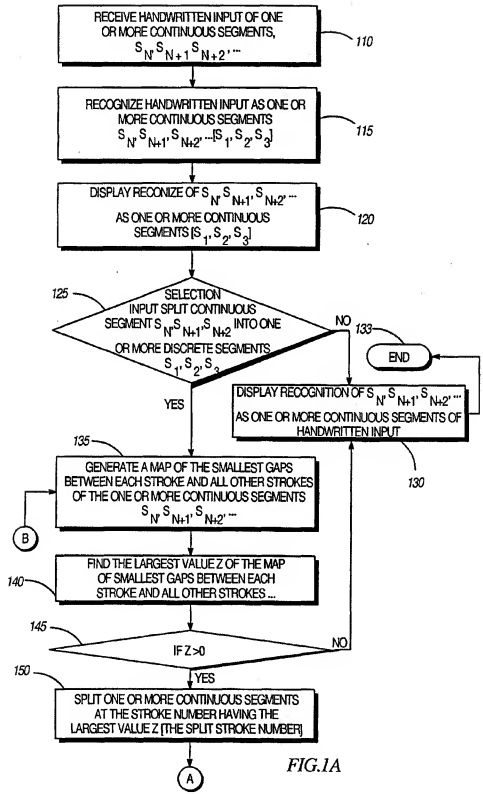
RECEIVE HANDWRITTEN INPUT OF ONE OR MORE CONTINUOUS SEGMENTS, $S_N, S_{N+1}, S_{N+2}, \ldots$
110
RECOGNIZE HANDWRITTEN INPUT AS ONE OR MORE CONTINUOUS SEGMENTS $S_N, S_{N+1}, S_{N+2}, \ldots [S_1, S_2, S_3]$
115
DISPLAY RECONIZE OF $S_N, S_{N+1}, S_{N+2}, \ldots$ AS ONE OR MORE CONTINUOUS SEGMENTS $[S_1, S_2, S_3]$
120
125
SELECTION INPUT SPLIT CONTINUOUS SEGMENT S_N, S_{N+1}, S_{N+2} INTO ONE OR MORE DISCRETE SEGMENTS S_1, S_2, S_3
NO
133
END
YES
DISPLAY RECOGNITION OF $S_N, S_{N+1}, S_{N+2}, \ldots$ AS ONE OR MORE CONTINUOUS SEGMENTS OF HANDWRITTEN INPUT
130
135
GENERATE A MAP OF THE SMALLEST GAPS BETWEEN EACH STROKE AND ALL OTHER STROKES OF THE ONE OR MORE CONTINUOUS SEGMENTS $S_N, S_{N+1}, S_{N+2}, \ldots$
B
140
FIND THE LARGEST VALUE Z OF THE MAP OF SMALLEST GAPS BETWEEN EACH STROKE AND ALL OTHER STROKES ...
145
IF Z>0
NO
150
YES
SPLIT ONE OR MORE CONTINUOUS SEGMENTS AT THE STROKE NUMBER HAVING THE LARGEST VALUE Z [THE SPLIT STROKE NUMBER]
A

FIG.1A

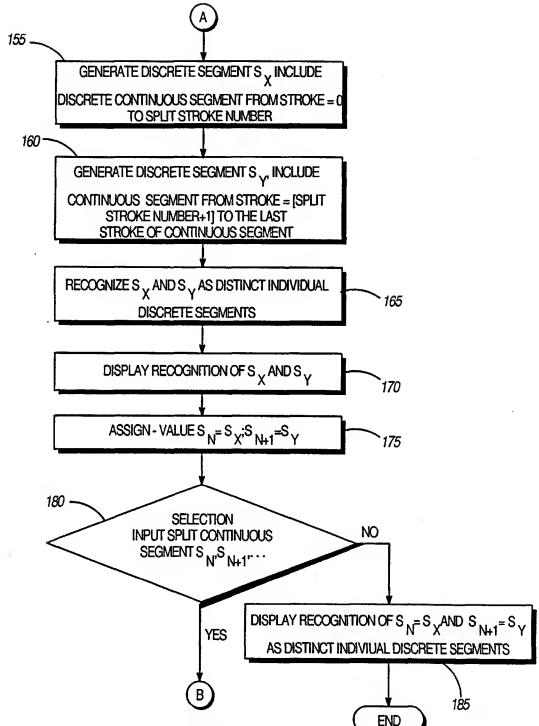
A
155
GENERATE DISCRETE SEGMENT S_X INCLUDE DISCRETE CONTINUOUS SEGMENT FROM STROKE = 0 TO SPLIT STROKE NUMBER
160
GENERATE DISCRETE SEGMENT S_Y INCLUDE CONTINUOUS SEGMENT FROM STROKE = [SPLIT STROKE NUMBER+1] TO THE LAST STROKE OF CONTINUOUS SEGMENT
RECOGNIZE S_X AND S_Y AS DISTINCT INDIVIDUAL DISCRETE SEGMENTS
165
DISPLAY RECOGNITION OF S_X AND S_Y
170
ASSIGN - VALUE $S_N = S_X; S_{N+1} = S_Y$
175
180
SELECTION INPUT SPLIT CONTINUOUS SEGMENT $S_N S_{N+1} \cdots$
NO
YES
DISPLAY RECOGNITION OF $S_N = S_X$ AND $S_{N+1} = S_Y$ AS DISTINCT INDIVIUAL DISCRETE SEGMENTS
185
B
END
188

FIG.1B

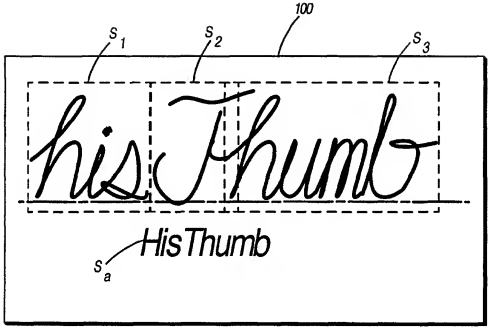
100
S1
S2
S3
his Thumb
His Thumb
Sa

FIG.2

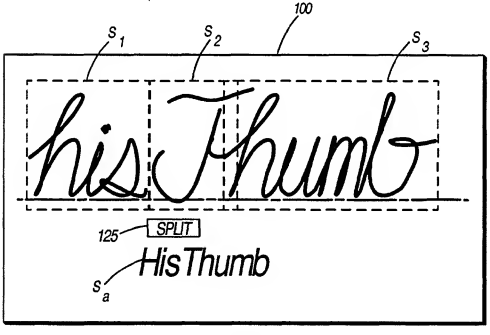
100
S1
S2
S3
his Thumb
125
SPLIT
His Thumb
Sa

FIG.3

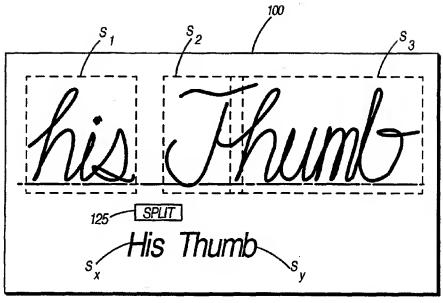

FIG.4

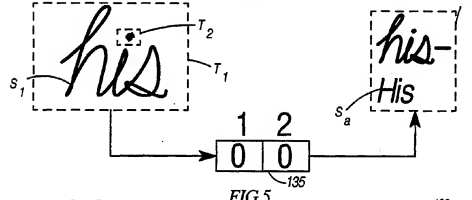

FIG.5

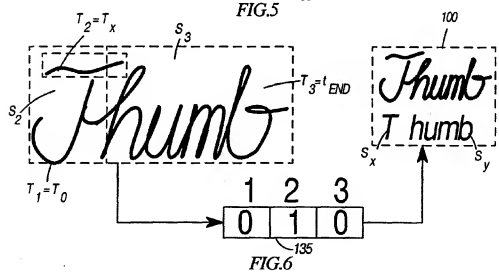

FIG.6

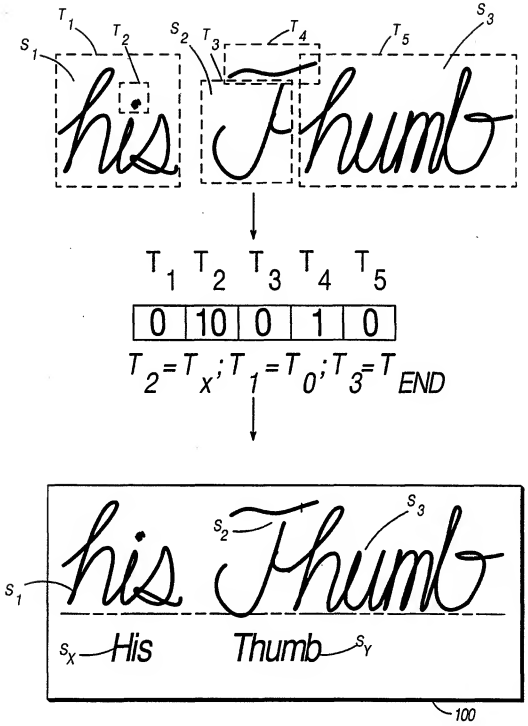
T1
T2
S2
T3
T4
T5
S3
S1
his Thumb
T1 T2 T3 T4 T5
0 10 0 1 0
T2=Tx; T1=T0; T3=T END
S3
S2
S1
his Thumb
SX
His
Thumb
SY
100

FIG.7